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OF

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OF

THE LEHIGH UNIVERSITY.

ISSUED QUARTERLY.

DECEMBER, 1887.

JOURNAL

OF

THE ENGINEERING SOCIETY.

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A. T. Throop, '89,
H. S. Jacoby, '77, *Corresponding Editor,*
L. R. Zollinger, '88, *Business Manager.*

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JOURNAL

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VOL. 3. DECEMBER. 1887. NO. 1.

ABSTRACT OF PROCEEDINGS.

September 29, 1887.—Vice-President McClintic in the chair, and eight members present. The following gentlemen were elected to membership: Messrs. W. L. Wilson and S. Yamaguchi from '88, A. T. Throop, A. W. Stockett, E. Diebitsch, J. J. Lincoln, R. M. Dravo, L. C. Taylor, J. Lockett, A. Johnston, J. R. Villalon and R. P. Barnard from '89. M. L. Byers, '88, read a paper on "Best Angles for Culvert Wing Walls." W. A. Stevenson, '88, explained the working of an "Automatic Bell-ringer for Locomotive Engines."

October 27.—President Davis in the chair, and twenty members present. Mr. C. H. Deans, '89, elected to membership. After some discussion, the Society decided to elect an Alumnus to be known as Corresponding Editor of the JOURNAL, his principal work being to solicit papers from the Alumni. Mr. H. S. Jacoby, '77, was unanimously elected. A. T. Throop was elected Editor from the Junior Class. Mr. S. Yamaguchi of Tokio, Japan, dressed in his native costume, gave a very interesting account of the progress of Engineering in that country.

November 10.—President Davis presided and there were eighteen members present. The following gentlemen were elected: Messrs. G. P. Dravo, J. H. Millholland, P. H. Dewitt and J. S. Mack from

'88; F. L. Grammar, A. D. Oberly, T. F. Newby, C. W. Hudson, G. Ayres, F. D. Campbell, J. Martin, J. W. Dougherty and C. E. Hesse from '89. Papers were read by S. H. Jencks, '88. on the "Oroya Railroad," and Mr. Villalon on "Slate Bricks." The latter exhibited several specimens of bricks manufactured at Phillipsburg, N. J. The President appointed the following committees: On Tunneling and Explosives—Messrs. Zollinger, C. Miller, Rickert; on Railroad Accidents—Messrs. G. Davis, Byers, Jencks; on River and Harbor Engineering—Messrs. McClintic, Wetzel, Bonzano; on Iron and Steel Manufacture—Messrs. Woods and Hart; on Bridge Construction—Messrs. Focht, Beatty, Yamaguchi; on Geodesy and Topography—Messrs. Shipman, Frescoln, Richards; on Steam Navigation—Messrs. Stevenson and Sattler; on Steam Engines and Pumping Machinery—Messrs. Polk, Glover, Bruegel; on Deep Foundations—Messrs. Raynor, Molt, Daniels; on Coal and Iron Mining—Messrs. F. Williams and Amsden; on Water Supply—Messrs. Parker, Bradford, Throop; on Artificial Building Materials—Messrs. Palmer, Villalon and G. Miller.

November 29.—President Davis in the chair. Sixteen members in attendance. The following gentlemen were elected to membership: Messrs. W. S. Davis, '88, W. A. McFarland, '88, A. M. Smyth and J. W. Anderson from '89. A paper on "Counterbalancing Connecting Rods" was read by Mr. Glover. On motion a committee on Constitutional Amendments was appointed. Committee—Messrs. Mack, Glover and Taylor.

December 8.—The meeting was called to order at 7.30 P. M. by the President. Thirteen members present. The following Amendments to the Constitution were proposed. Art. iv. sec. 2, to read: "The students in the Schools of Engineering after entering upon the Junior Year may become active members," etc. Amendments. —Art. iii. Publications. 1. The transactions of the Society shall be published in a pamphlet issued quarterly, to be called the "Journal of the Engineering Society of the Lehigh University." The Board of Editors of this Journal shall consist of the following: A Business Manager, to be chosen from the Senior Class; two Editors, one from the Senior and one from the Junior Class, and a Corresponding Editor, to be chosen from the Alumni. The Editor from the Senior Class not elected as Business Manager shall be Editor-in-Chief. 2. The Business Manager and all the Editors of this Board, except the Junior Editor, are to be chosen at the

same time, and in the same manner as the officers of the Society; the Junior Editor to be elected at the first meeting of each college year.
C. J. Parker, Secretary.

SLATE BRICKS.

The following notes were collected on a visit to the American Brick and Tile Company's works, Phillipsburg, N. J.

This is the only manufactory of slate bricks in the country, and although started but a year ago, it has been necessary to enlarge its plant to fill the constantly increasing orders.

It employs about 30 men and boys and has a capacity at present for 20,000 bricks per day; this number will be considerably increased this Winter when the new steam presses are substituted for the hand presses now in use.

The substance used in making these bricks is the rubbish from the slate quarries. This rubbish is thrown into a crusher, from which it passes to a grinding pan, where the first grinding is done. An elevator takes the ground slate to a J. T. Noyes rolling machine, which reduces it to a fine powder. The process is similar to that used in the flour mills. From the roller it goes into a pug-mill, where water is applied in sufficient quantity to make a paste, and then it comes to the brick machine; this is a common machine of 60 bricks capacity per minute. Here the moulds are placed upon an endless belt, from which they are taken off and put on a floor heated by steam, to be dried. These bricks are now called *green common* bricks. After remaining upon this floor for about two hours they are fit for the presses. After they are pressed they are called *green pressed* bricks, until they are dried sufficiently to go in the kiln, when they are called *dried pressed* bricks. The presses used at present are hand presses, in which the green common brick is subjected to a pressure of about 7 tons. During the coming Winter steam presses will be substituted for the hand presses. These give a greater pressure to the brick and have a capacity of 15,000 bricks per day of 10 hours.

The bricks, after having been pressed and dried, are taken to the kiln to be burnt. A good size kiln is 48 by 30 feet, which contains 200,000 bricks; others of smaller dimensions contain 140,000 and 120,000 bricks. They are set in the kiln in the ordinary way. The fire is applied below, on both sides of the kiln;

the fuel used is large egg coal. The bricks are burnt hard and at a temperature of white heat.

It takes four days and four nights to burn a kiln out, and from three to four days to cool it. In cooling the kiln the fire is not smothered as for clay bricks, but left to extinguish itself naturally after the fuel has burned out. The burner judges when the bricks are burnt enough by the color of the flame in the arches and the smoke given off at the top of the kiln. A large kiln of dimensions above given consumes about 45 tons of coal for one burning, and the others the same in proportion to the surface exposed. The different kinds of brick are: 1. Salmon; 2. Hard common; 3. Pressed standard; 4. Fine pressed; 5. Paving brick. The *salmon* are not pressed, and being placed nearest to the walls of the kiln they are not very hard. Their cost on car at the factory is $7.50 per M. *Hard common* are the same as salmon, but burnt harder; $9.00 per M. The cost of the other kinds is as follows:

Pressed brick, from $12 to $20 per M.
Paving brick, from $12 to $13 per M.
Clinker, or arch brick, $8.50 per M.

The slate brick have all the qualities of good ordinary brick; they are very hard; the sound is clear and rings like a piece of steel; the texture is compact and homogeneous; the grain is fine and free from pebbles and the bricks do not crack.

The test for absorption of water shows that this kind of brick absorbs only 6 ounces of water or about 7 per cent. of its weight, against one pound or about 15 per cent., absorbed by the clay brick.

The ultimate crushing strength of hard-burned pressed brick is 7600 pounds per square inch. That of same quality of clay brick made at Pittsburg, Pa., is 3800 pounds per square inch; the strength of the slate being thus double that of the clay.

In regard to the flexure or bending test, no experiments have been made.

The size of a brick is $8\frac{1}{2}'' \times 4'' \times 2\frac{1}{4}''$, and it weighs 5 pounds.

The advantages of slate bricks over the clay bricks are many, of which the following are the principal ones: The slate brick does not shrink or change in shape when burnt, but keeps the same size and shape which it had when it was green. A circle can be formed of a certain number of square bricks and after these are burnt they will form a perfect circle as before. This is a quality which has not been obtained with the clay. A kiln of clay

bricks settles while burning, sometimes as much as two feet, and the burner judges his bricks by the settling of the kiln; slate bricks do not show any considerable settling.

As the slate brick absorbs so very little water, it does not take the life from the lime, therefore the mortar does not set so quickly and leaves the lime and the sand more like a cement, and the adhesion is greater. On the contrary, the clay brick absorbs the water of the mortar quickly. This destroys the life of the mortar by changing the proportions of its elements, so the bricks get loose very easily. Neither the moisture of the atmosphere nor the rain water is absorbed to any extent through the slate brick. They "wet in" scarcely ¼ of an inch, leaving the rest of the wall perfectly dry, and diminishing considerably the dampness of the buildings. A mason can cut them exactly in the place and direction in which he applies his trowel. The weather has no effect upon these bricks at all, and they can be made all the time during the Winter. Experiments made at the factory last Winter show that frost has no effect upon them. If a kiln of clay bricks in process of setting gets frozen, the moment the heat is applied to them they will crumble; slate bricks will burn just as well whether they were frozen or not.

Slate bricks never lose their color nor present those white discolorations of the clay brick, but, on the contrary, the colors become brighter the longer they are exposed to the weather.

Slate bricks being stronger and absorbing less water than clay bricks are more fit for arching, sewerage, or any kind of building for underground work.

The pavement made of this kind of bricks is very fine: they present a smooth surface, and they do not hold the ice like other pavements, but like the slate are cleansed of the ice very easily.

This is a kind of brick which, when generally known, will be found to be far superior to any other brick, both as to durability and beauty, and will in time take the place of the clay brick in all its applications.

Among the buildings in which these bricks have been used are: The Lehigh Valley Railroad Company's new offices and the new Music Hall in South Bethlehem, Pa.; the Phillipsburg Stove Works, Mr. J. Crater's large store-house in Phillipsburg, N. J.; Mr. Shiffer's three-front house in Easton, Pa., corner of Ferry and Walnut Streets.

José R. Villalon.

THE BEST ANGLE FOR CULVERT WING-WALLS.

During the last Summer my attention was attracted to the economy of construction of culvert wing-walls by seeing several plans differing from the usual form in that the wing-walls were parallel to the axis of the culvert instead of being at an angle of about 30° therewith.

I consulted all the authorities at my command with no other result than the statement that the wing-walls should be built at an angle of 30° with the axis of the culvert. A number of old plans which I obtained gave the angle as between 30° and 33°, the latter of which, I believe, was at one time almost universally used on the Pennsylvania Railroad. Not being able to find any reason for the choice of this angle, I determined to find the economical deflection angle for myself, if possible.

First, an equation for the volume for different heights and angles was derived, but it proved too complicated for solution.

Next, a more successful attempt was made to obtain the angle by experiment.

There are two cases to be considered:

First, when the wing-wall reaches to the edge of the slope.

Second, when the wall is just long enough to prevent the earth flowing around its lower end from getting into the channel of the stream.

In the first case, which is the common one, it is evident that the wall will be shortest when the angle $a=0$, increasing in proportion to the secant of a. Now, the pressure on the wall is dependent upon the height of earth behind it, and hence we cannot make the wall thinner by increasing the angle a.

It becomes evident, then, that, for a given height, the wing-wall will contain the least amount of masonry when $a=0$.

In the second case, we may obtain the length of the wall and its height at the lower end as follows:

Let l=A B=length of wing-wall.
" h=height at A.
" h_1=height at B.
" t_1=thickness bottom of wall at A.
" t_2=thickness bottom of wall at B.
" l_1=B C.
" l_2=A C.

Let l_3=A F, E F representing the bottom of the slope.

" b=slope ratio of bank ($=\frac{3}{2}$).

Then, $l_3=bh=l_1+l_2$

for B E=B D since the earth would flow as far from B in one direction as in the other.

$l_1=l\ cos\ a$ and $l_2=l\ sin\ a$.

$$\therefore bh=l\ sin\ a+l\ cos\ a,\ or\ l=\frac{bh}{sin\ a+cos\ a}$$

$$l_2=bh_1=l\ sin\ a=\frac{bh\ sin\ a}{sin\ a+cos\ a},\ \text{or}$$

$$h_1=\frac{h\ sin\ a}{sin\ a+cos\ a}$$

These equations give such values that the dirt flowing around the end of the wing will stop two or three feet (depending upon the thickness of the lower end of the wall) from the edge of the channel of the stream, thus not interfering with the flow of the water. Using the above formulæ to obtain the values of l and h_1, volumes for wing-walls of ten and twenty feet in height were computed approximately for every fifteen degrees from zero to ninety. The following table shows the result:

h	h_1	l	t_1	t_2	Ang. a	Vol. Cu. Yds.
10	10	15	5	5	90°	21
20	20	30	10	10		133
10	7.9	12.2	5	3.9	75°	14
20	15.7	24.5	10	7.8		92
10	6.1	11	5	3.1	60°	11
20	12.6	22	10	6.3		72
10	5	10.6	5	2.5	45°	9.5
20	10	21.2	10	5		63
10	3.1	11	5	2	30°	9
20	7.2	22	10	3.6		59
10	2.1	12.2	5	2	15°	9.5
20	4.2	24.5	10	2.1		60
10	0	15	5	2	0°	10.5
20	0	30	10	2		69

These calculations were made on the supposition that $t=\frac{h}{2}$ when greater than 2 feet, and that the width of the coping was 2 feet 6 inches, allowing it to project 3 inches on each side. The value of t is probably greater than necessary; Trautwine gives it as $\frac{4}{10}h$, but this will not materially alter the comparison.

Angle a	0°		15°		30°		45°		60°		75°		90°	
	Vol.	Pr.Ct	Vol.	Pr.Ct	Vol.	Pr.Ct	Vol.	Pr.Ct	Vol.	Pr.Ct	Vol.	Pr.Ct	Vol.	Pr.Ct
10 ft. wall	10.5	117	9.5	106	9	100	9.5	106	11	122	14	156	21	233
20 ft. wall	69	118	60	103	59	100	63	108	72	123	91	156	133	230

It would appear from the above tables that, for the 10-foot wing-wall, the angle a should be about 30 degrees, while for the 20-foot wall it should be between 25 and 30 degrees. To obtain closer results, these calculations might be made for each degree from 25 to 35, but there is but little use in so doing, as this form of wing-wall is never used owing to the danger of having the exposed portion of the embankment swept away by floods.

The case in which the angle $a=0$ would also apparently expose the embankment to the action of water, but in this case it could be easily protected by rip-rap.

At any rate, the culvert should be made large enough to carry off all floods without causing the water to dam up, in which case the banks would be in no especial danger. Hence, it seems that, except when appearance is an important consideration, the wing-wall with its face parallel to the axis of the culvert is to be preferred as being the most economical consistent with safety.

M. L. BYERS.

THE OROYA RAILROAD, PERU.

The Oroya Railroad is a line which starts from the Pacific Coast at Callao, follows the valley of the Rimac River, upon a continually ascending grade, to the source of that stream, and crosses the summit of the Andes through a tunnel at the height of 15,645 feet above sea level.

The projected line runs to Oroya, a town situated on one of the feeders of the Amazon River, and is 136 miles in length.

Notwithstanding the formidable obstacles that intervened, the line has been constructed beyond the highest point of the Andes. With its stupendous gradients and zigzag windings up the mountain slopes, it is assuredly one of the grandest engineering undertakings in the world.

After the first 39 miles has been passed, the road pursues its course through deep cuts and tunnels, in spite of all obstacles, shaping itself to the outline of the mountains, and ascending with unfaltering steadiness from height to height at a grade of 210 feet to the mile.

This railroad ascends to a height only 136 feet below that of Mont Blanc—the most elevated point at which steam ever worked a piston. This great elevation is reached by means of zigzag or

horseshoe developments, switchbacks, or by a combination of these two.

It may be inferred how impossible it would be to follow the river's track without these retrograde movements, when it is said that the rate of fall of the river becomes as great as 10 per cent. to 12 per cent., and at certain places even as great as 15 per cent.

In ascending several of the retrograde developments found on this line, the engine, when it stops opposite the station, is detached from the cars, and advances to a turntable, where it is brought round on to another track. It then comes back parallel to the line by which it came up, until connected by switches with what on the ascent to this was the hindmost car of the train, and, after making a detour through a great cutting, progresses up the mountain sides on 4 per cent. grades.

The contour of the mountain is such that in many places the distance by line of road is from three to four times the air-line distance between two places.

From the station of San Bartolome to a certain point, the horizontal distance is 855 feet, but by line of road it is 3⅓ miles. At another place, the train goes through two points only 465 feet distant horizontally, but the distance vertically is 533 feet, showing an average slope steeper than 1 to 1.

Many such places were entirely inaccessible to bipeds, and the line was only located by making as careful a topographical map as possible, projecting a location and triangulating in points on it for beginning construction.

Near Chicla, a combination of switchbacks and horseshoes are found. Here 4.9 miles of road has 1776° of curvature—an average of 362° to the mile. The railway winds along the edge of precipices, and crosses from cliff to cliff on bridges that seem suspended in air. The bridge at Verrugas is one of the highest in the world, and spans a chasm 580 feet wide. It is of the Fink type, and rests on three piers, the central one being 252 feet high. After ascending a grade of 105—211 feet to the mile for 23 miles, the line reaches a chasm known as the "Little Hells." At this point the river passes between two walls of rock, about 2,500 feet high. In passing under these high points, the line leaves one tunnel, crosses the run on a bridge whose height is 165 feet above the water, and enters another tunnel. In driving these tunnels, the workmen were lowered by ropes from the top of the

cliff, and hanging in that way they hammered at the face of the rock until they had cut themselves standing room.

The number of tunnels on this road averages one tunnel for every two miles. On one part of the line there are 8 tunnels within 4¾ miles, in some of which there are curves whose radius is 395 feet.

The construction of the tunnel which was built at the great elevation of over 15,000 feet was attended with unparalleled difficulties, demanding unceasing effort and the greatest powers of endurance. All the machinery for boring and working the approaches came from the workshops of Lima, and were brought on the backs of mules from the terminus of the rail. In the progress of the tunnel, every step was impeded by snow-water percolating from above, often bursting through seams, and driving the laborers from their work. And, although the most hardy men were employed, and those most inured to the painful effects of a very rarified atmosphere, yet even they were frequently discouraged by their many trials.

It cost the Government $200,000 per mile for the construction and equipment of the line. This, however, included everything, the survey, construction, and the right of way, besides furnishing all supplies, the building of necessary docks at Calloa, of stations, freight and engine houses, and the supply of a certain number of engines, coal, freight, and passenger cars. The rolling stock and ties were imported from the United States and the rails from England. As all the plant for the construction of the road had to be transported by mules, the cost of new mule-paths to replace those occupied by the rails, as they advanced, is estimated to have been $500,000. The powder for blasting purposes alone amounted to over 5,000,000 pounds.

Should the object of this great undertaking be accomplished, it will be possible, by means of this railroad and the Amazon River, to make a complete passage from ocean to ocean across the widest portion of South America. S. H. Jencks.

COUNTERBALANCING CONNECTING RODS.

It is my object in this paper to deduce an expression for that proportion of the connecting rod of a steam engine which should be regarded as a rotating part, and consequently counterbalanced; and also to determine if this proportion is constant for all crank angles. I have no doubt that such an expression can be found in

works on such subjects, but being unable to find it I deduced it for myself; and as it is a matter of considerable importance, especially in high-speed vertical engines, that the rod should be properly counterbalanced, I thought it might be of interest to the Society.

Suppose, to simplify matters, the crank end of a connecting rod to be released from the crank pin, and, instead of moving in a circle, to move in the same straight line as the centre of the piston-rod; suppose, also, that the piston be geared to the crank-shaft in such a manner that the relative motion between the two parts remains the same. Now, again, suppose some outside force, which we will call P, to be applied to the crank end of the connecting rod thus released, so that the connecting rod follows exactly the same path as when attached to the crank pin; this force P being always perpendicular to the medial line of the connecting rod. We will suppose the engine of which we are treating to be of the horizontal type. Now it is evident that the vertical component of this force P must be equal to the vertical component of the centrifugal force of the counterweight, if the rod is properly counterbalanced, and the vertical forces are in equilibrium.

To find the intensity of this force P, we proceed as follows:

Let M=weight of connecting rod.
" R=radius of crank circle.
" a=ratio of length of connecting rod to length of crank.
" bR=distance of centre of gravity of rod from centre of cross-head pin.
" W=angle of inclination of connecting rod from the horizontal.
" x=angular travel of crank pin measured from dead centre nearest cylinder.

Now we have $\cos W=\frac{1}{a}\sqrt{a^2-\sin^2 x}$ (See p. 57, No. 2, Vol. II.)

It is plain that the angular velocity of the connecting rod about the cross-head pin as a centre will vary as $\frac{d W}{d x}$, and that the necessary acceleration, and consequently the force required to produce this acceleration will vary as $\frac{d^2 W}{d x^2}$.

$$P \propto \frac{d^2 W}{d x^2} = \frac{d^2 \left[\cos^{-1}\left(\frac{1}{a}\sqrt{a^2 - \sin^2 x}\right)\right]}{d x^2}$$

$$\frac{dW}{dx} = \frac{\cos x}{\sqrt{a^2 - \sin^2 x}} = \sqrt{\frac{1 - \sin^2 x}{a^2 - \sin^2 x}}$$

$$\frac{d^2 W}{dx^2} = \frac{(a^2 - 1)\sin x}{(a^2 - \sin^2 x)^{\frac{3}{2}}}$$

$P = C\dfrac{(a^2 - 1)\sin x}{(a^2 - \sin^2 x)^{\frac{3}{2}}}$ in which C is a constant which is as yet undetermined. We will designate the vertical component of P by V_1. Now if a figure be drawn it will be apparent after a moment's inspection that $V_1 = \cos W P_1$. Substituting the values of $\cos W$ and P, we get:

$$V_1 = \frac{1}{a}\sqrt{a^2 - \sin^2 x}\left(C\frac{(a^2 - 1)\sin x}{(a^2 - \sin^2 x)^{\frac{3}{2}}}\right) = \frac{C}{a}\,\frac{a^2 - 1}{a^2 - \sin^2 x}\sin x$$

We now wish to determine the value of the constant C. When the crank is at 90° from a dead centre, both ends of the connecting rod are moving in the same direction, so in that position the rod may be regarded as infinite in length. Now when the connecting rod is infinite in length, as far as the force of inertia is concerned, it may be treated as a mass concentrated about the crank-pin, in which case the vertical component of the force of inertia of the mass would be the centrifugal force of the mass multiplied by $\sin x$, or

$V_1 = \dfrac{m v^2}{R} \sin x$, in which m is the mass concentrated about the crank pin, and v is the velocity of motion of the crank pin.

Equating the two values which we have found for V_1 when $x = 90°$, we get:

$$\frac{C}{a}\,\frac{a^2 - 1}{a^2 - \sin^2 x}\sin x = \frac{m v^2}{R}\sin x$$

and $C = \dfrac{a m v^2}{R}$

Substituting this value of C in the first expression which we found for v, we have

$$V_1 = \left(\frac{m v^2}{R}\right)\left(\frac{a^2 - \sin x}{a^2 - 1}\right)\sin x$$

This equation we derived under the supposition that the mass of the connecting rod was concentrated about the crank pin, but if the centre of gravity of the rod is at a distance equal to $b R$ from the cross-head pin, then the vertical force will be

$$V = \frac{b}{a}V_1 = \left(\frac{b}{a}\right)\left(\frac{m v^2}{R}\right)\left(\frac{a^2 - 1}{a^2 - \sin^2 x}\right)\sin x$$

In order to counterbalance this force, the vertical component of the centrifugal force of the counterweight must have the same value. Let R_1 equal distance of centre of gravity of counterweight from centre of shaft, and let m_1 equal its mass. Then the vertical component of the centrifugal force of the counterweight will be given by $\frac{m_1 v_1^2}{R_1} \sin x$, in which v_1 is the velocity of motion of the centre of gravity of the counterweight. But $v_1 = \frac{R_1}{R} v_1$ hence

$$\frac{m_1 v_1^2}{R_1} \sin x = \frac{m_1 R_1}{R^2} v^2 \sin x.$$

This must be equal to V, hence,

$$\frac{m_1 R_1}{R^2} v^2 \sin x = \left(\frac{b}{a}\right)\left(\frac{m v^2}{R}\right)\left(\frac{a^2 - 1}{a^2 - \sin^2 x}\right) \sin x$$

and $m_1 = \left(\frac{R}{R_1}\right)\left(\frac{b}{a}\right)\left(\frac{a^2 - 1}{a^2 - \sin^2 x}\right) m.$

From this we see that m_1 is not the same for all values of x, and consequently that the connecting rod can only be perfectly balanced for one value of x. The least value which a commonly has is 4, hence the greatest range of the variable $\frac{a^2 - 1}{a^2 - \sin^2 x}$ is from $\frac{15}{16}$ to 1. Since V is at a maximum when $\sin x = 1$, it would be best to have the rod perfectly balanced for this value of x, so $\frac{a^2 - 1}{a^2 - \sin^2 x}$ should be taken as equal to 1, and the value of m_1 becomes

$$\frac{R}{R_1} \cdot \frac{b}{a} \cdot m$$

This is the maximum value which the counterweight can have. In horizontal engines it is customary to counterbalance only from 50 to 80 per cent. of the vertical force V. As in practice $\frac{b}{a}$ varies from about ½ to ⅔, m_1 is usually taken as $0.50 \times \frac{2}{3} \times \frac{R}{R_1} m = \frac{1}{3} \cdot \frac{R}{R_1} m.$

In vertical engines, this force V becomes a horizontal force, and should therefore be as nearly counterbalanced as possible, since in this case the foundation cannot be depended upon to absorb any of this force. In this type of engine, then, m_1 should be taken

as very nearly equal to $\frac{R}{R_1}\frac{b}{a} \cdot m$.

In designing a high-speed vertical engine, it would be advisable to determine the value of $\frac{b}{a}$ carefully by experiment, so that the exact value of m_1 may be found.

J. B. Glover, Jr.

BRIDGE SPECIFICATIONS.

General Specifications for Railroad Bridges. Issued by the Bridge and Construction Department of the Pencoyd Iron Works. Philadelphia, 1887.

Standard Specifications of the Phœnix Bridge Company for Railway and Highway Bridges and Viaducts. Phœnixville, 1887.

General Specifications for Highway Bridges of Iron and Steel. By J. A. L. Waddell, Consulting Engineer, Kansas City, Mo., 1887.

The manner in which the impact, or increased stresses, caused by the rolling load shall be taken into account in proportioning bridge members is as yet unsettled, so that there is great diversity in the methods in common use. The method of the Pencoyd specifications is a new one, and is stated as follows :

" In proportioning the members of the structures, the effect of impact and vibrations shall be considered and added to the maximum strains resulting from the above-mentioned engine and train-loads. The effect of impact is to be determined by the following formula :

$$I = S\left(0.7 + \frac{5}{L}\right)$$

where $I =$ effect of impact, $S =$ calculated maximum live-load strain, $L =$ length of loaded distance in feet which produces the maximum strain in member. For plate-girders, $L =$ span, centre to centre bearing. For floor-beams, $L =$ length of two panels. For truss-bridges $L =$ number of panel-points loaded, multiplied by length of panel. * * * * * All parts of the structure shall be so proportioned that the sum of the maximum loads, together with the impact, shall not cause the tensile strain to exceed —ON WROUGHT IRON, 15,000 pounds per square inch on tension bars, and 14,000 pounds per square inch on shapes and plates ; ON STEEL, 18,000 pounds per square inch."

The Phœnix specifications follow the older method of making no direct allowance in the computed stresses for impact or repeated strains, but effect the result by stating low values of the unit-stresses which are to be used in proportioning the members. They specify, for example, for wrought iron in railroad bridges: In counters and long verticals, 8,000 pounds per square inch; in eye bars, 10,000; in suspension loops and plates, 7,000; in the bottom flanges of rolled beams and plate-girders, 8,000; in angle-iron lateral ties, 12,000 pounds. The method of Mr. Waddell is the same, but his unit-stresses, being for highway bridges, necessarily differ somewhat from those just stated.

In order to compare the two methods, let us take the case of a floor-beam in a railroad bridge with 20-foot panels, and suppose the loads to be such that the flange-stresses are found to be 6,900 pounds from the dead load, and 59,700 pounds from the live load. By the Pencoyd specifications the effect of impact is:

$$I = 59{,}700 \left(0.7 + \frac{5}{40} \right) = 49{,}250 \text{ pounds.}$$

and then the net section of the lower flange is,

$$A = \frac{6{,}900 + 59{,}700 + 49{,}250}{14{,}000} = 8.27 \text{ square inches.}$$

By the Phœnix specification the lower flange net section is directly found thus:

$$A^1 = \frac{6{,}900 + 59{,}700}{8{,}000} = 8.33 \text{ square inches.}$$

The two values are practically the same, but while the second method gives the same value of the section, whatever be the panel length, provided the stresses remain the same, the first method gives a larger value of A for shorter panels; thus for 10-foot panels A would be 8.81 square inches. Again, for eye bars in a span of 200 feet, let S be the live-load stress in any member, and D the dead-load stress, then the Pencoyd specifications give

$$A = \frac{D + S + 0.725\ S}{15{,}000}$$

and the Phœnix specifications give

$$A^1 = \frac{D + S}{10{,}000}$$

If $A = A^1$, we find $D = 0.45\ S$, and as this is about the usual relation between dead and live loads for a span of 200 feet, we conclude that the two methods are in substantial agreement.

Neither of these methods appears so satisfactory and rational as

that founded on the experiments of Wöhler, and given by Mr. Joseph M. Wilson in the standard specifications of the Pennsylvania Railroad Company. We are unaware of any rational basis for the formula of the Pencoyd Company except its accordance in special cases with the older establised methods and its general agreement with the well-known dynamical rule regarding the effect of suddenly applied stresses.

The high unit stresses of 15,000 and 14,000 pounds for wrought iron in tension seem to indicate, however, that the effect of the impact has been overestimated in the formula. For, if the impact really causes a stress equivalent to seven-tenths or more of the live-load stress, then the working stress of 14,000 pounds on shapes in tension gives a factor of safety of only about 3½ based on the ultimate strength, and of about 1¾ based on the elastic limit. It is very much to be desired that more experimental knowledge should be obtained regarding the effect of repeated stresses and suddenly applied live loads. If bridge companies would make experiments in this direction they would tend to render the methods of design more uniform by rendering it possible for railroad companies and other buyers of bridges to specify more rational methods of proportioning members.

Professor Waddell is well known as the author of an excellent work on the designing of highway bridges, as a scientific investigator and teacher of experience, and as a thorough practical expert on bridge construction. In the pamphlet before us are given not merely excellent general specifications for four classes of highway bridges, but also much matter of great value to county commissioners, borough councilmen and others who have occasion to buy bridges, but who have not had the engineering training to render them proficient in judging as to the quality of designs. It is well known to engineers that there are contractors and manufacturers who are ready to take advantage of the lack of technical knowledge of county commissioners, by selling and erecting bridges which are of inferior quality, if not positively dangerous. The words of warning here so ably set forth by Mr. Waddell will prove of great advantage if generally read and heeded by county commissioners. Opening with an introductory chapter on the methods employed by unscrupulous contractors and the consequent insecurity of many existing bridges, the pamphlet treats in successive chapters of highway bridge failures, of bridge lettings, of how highway bridges are built, and of how they ought to be

built, and then suggests as a remedy an association of bridge-builders whose object should be to protect the public from the erection of inferior structures by creating a public sentiment in favor of thorough specifications, sound inspection by competent experts, and the warranting or insuring of structures properly planned and erected.

Highway bridge construction stands upon an essentially different footing from railroad bridge construction, owing to the fact that the railroads employ civil engineers who are competent judges of bridges, while counties and boroughs often purchase and erect highway structures without any expert advice whatever, relying solely upon the business capacity of commissioners and councilmen. It is to be hoped that the time will come when the general public will appreciate the fact that a bridge is a complex structure which requires great technical skill to design and erect so that it will be both safe and economical, and that this result can only be successfully attained when all the operations, from the drawings of the specifications to the testing of the finished bridge, are supervised by civil engineers of thorough training and long experience. The pamphlet of Professor Waddell has great value in drawing the attention of the public to this important subject in a clear and forcible manner, while his specifications will certainly prove suggestive and useful to bridge experts and civil engineers in general.

MANSFIELD MERRIMAN.

THE SOUTH BETHLEHEM WATER WORKS.

READ BEFORE THE BETHLEHEM ENGINEERING SOCIETY AT THE MEETING ON DEC. 13, 1887.

The new plant of the Bethlehem South Gas & Water Company consists of the pumping station, the reservoirs and the system of distributing mains. The source of our water supply is the Lehigh River.

The pumping station is located on the south bank of the river, opposite Calypso Island. The pumping engine was built by the Dickson Manufacturing Company of Scranton, Pa., and may be described as a "compound beam and fly wheel condensing steam pumping engine," having vertical inverted cylinders mounted on columns, said columns supported on the bed-plate which rests on the foundation. The high pressure cylinder is 13¼ inches

diameter, and the low pressure cylinder 26½ inches diameter, and the stroke 54 inches. Each cylinder crosshead is connected by a link to either end of the beam to which the pumps are connected, and from which they are operated. The main connecting rod is actuated from a pin placed in the upper part of the beam and extends to the crank which operates the crank shaft and fly wheel. The valve gear is actuated by gears from the main crank shaft. The cylinder valves are of the multiported gridiron type, sliding upon a seat formed in the cylinders and worked by rockers which are actuated by eccentrics on the cam shaft. The cut off is automatic, and is controlled by a ball governor. The steam cylinders are steam jacketed on sides and ends, and are fitted with a copper expansion joint to allow for difference in expansion of the walls of the cylinders.

The exhaust from high pressure cylinder to low pressure cylinder passes through a copper pipe, which is also steam jacketed, and filled with live steam to prevent radiation or loss of pressure.

The fly wheel is 18 feet in diameter and weighs 8 tons.

The condenser is of the jet type. The air pump is horizontal and double acting with cylinder 12″ x 16″ stroke. The pumps are vertical duplex, worked by links from the main beam, and resting upon adjustable screws, and shoes at the bottom of the pit. The plungers are 15¾ inches diameter and 30 inches stroke. Each pump has 26 delivery valves and 28 suction valves.

There is a large air chamber common to both of the pumps on the discharge pipe, and in addition each pump is provided with a vacuum or suction chamber.

The regular speed of the engine is 30 revolutions, or 270 feet piston speed per minute; that of the pump plungers is 150 feet per minute. Running at this speed during a 12 hour test, made on Aug. 6, 1887, the total displacement of pumps was 1,132,185 gallons. Actual running time, 12 hours 26 minutes on a consumption of 2500 lbs. pea coal. This is more than the guarantee which was 1,000,000 gallons in 12 hours on 2500 lbs. coal. Steam is supplied to the engine by one of the two 100 horsepower boilers in the boiler house immediately adjoining the engine house. The boilers are return tubular 66″ diameter and 16 feet 6″ long, each boiler containing 107 tubes, 3″ diameter. They are made of the best quality of Otis steel, and were built by McKee & Milson of Bethlehem.

Feed water for the boilers is taken from the hot well at a temperature at from 90° to 100° and forced into the boiler by a small injector in constant operation gauged to keep up the supply.

The reservoirs are located on the Lehigh Mountain immediately west of St. Luke's Hospital, at an elevation of 245 feet above the Lehigh River, and a distance of 1200 feet from the pumping station.

The two reservoirs are separated by an earth embankment with sloped sides, but are connected by a 16 inch pipe through this bank, placed about 4 feet above the bottom of each reservoir, in which pipe is placed a stop valve by means of which the reservoirs can be used separately or together.

An important feature of the reservoirs is the valve house, which is located at the eastern end of the middle bank, about 15 feet distant from each reservoir. The valve chamber over which it is built extends down to a depth of about 2 feet below the bottom of the reservoirs. Both the pumping and distributing mains centre in this valve chamber, and by means of suitable connections diverge into the reservoirs, both mains being provided with valves for turning the water to or from each reservoir; connected with the distributing main, and in the centre of the valve chamber, is the overflow standpipe, 36 inch diameter, which is gauged to overflow with 15 feet depth of water in the reservoirs, such overflow being discharged into the valve chamber, and from there through a 12 inch sewer pipe down into the river. The 6 inch mud pipes laid from the bottom of the reservoirs also extend and discharge into the valve chamber where the valves are placed for drawing off the water for cleaning or repairing when necessary or desirable. This system of connecting the two reservoirs is so complete and convenient that any required repairs or cleaning can be accomplished without interfering in the least with the water supply to the towns; and it is surprising that any town would take the risk of a continuous water supply from a single reservoir, when with a comparatively small additional outlay a double reservoir can be built. The capacity of the reservoirs is 3,000,000 gallons with 15 feet depth of water. They were built on a carefully selected site, numerous test pits having been sunk to ascertain the character of the soil and rock before the excavation was begun, every possible care being taken to secure a firm and solid foundation for holding this body of water. All porous soil and decayed rock were carefully removed from the bottom of the

excavation as well as from the foundations for the embankments, and all roots and decayed or vegetable matter as well as all stones or gravel were separated from the earth which was used for making the embankments and sides. After being thoroughly tamped and rolled in thin layers with heavy grooved rollers, the bottom and sides were puddled with a layer of clay 12 inches thick, on which was placed another layer, 12 inches thick, of concrede made of hydraulic cement and broken stone, making a solid and compact mass. This mode of construction, though expensive, on account of large amount of clay required, which was freighted here on cars from Lehighton on the Lehigh Valley Railroad, was adopted after a careful consideration of various other methods of reservoir construction, and we have thus far no reason to regret its adoption.

The work was satisfactorily done by Messrs. Brown & Goodnow, contractors, who also deserve credit for the conception and successful working of the novel and inexpensive plane by means of which all the clay and heavy materials were raised up the steep side of the mountain, at a trifling cost per ton, with a small portable steam engine of not over 8 horsepower.

The following results were obtained at a test of the pumping engine made on Aug. 6, 1887:

Wood used to start fire	215 lbs.
Wood used in coal equivalent @ 0.4=	86 lbs.
Coal consumed (Pea)	2414 lbs.
Coal, and wood in coal equivalent	2500 lbs.
Ashes and clinker, at close of trial	355 lbs.
Per cent. of ashes	14.2
Combustible (2500—355)	2145 lbs.
Running time of engine	12 hrs. 26 min.
Total revolutions of engine	22,373
Total displacement of pumps	1,132,185 gals.
Revolutions in 12 hours	21,620
Displacement of pumps in 12 hours	1,094,080 gals.
Coal consumed in 12 hours	2416 lbs.
If the coal had contained 7½ per cent. of ash, which is a liberal allowance for good coal, the coal used to pump the 1,132,185 gallons would have been	2333 lbs.
instead of 2500 lbs., or the 2500 lbs. coal, with 7½ per cent. ash, would have pumped	1,208,041 gals.
On the same basis, if ash had been 7½ per cent., the coal used in 12 hours to pump 1,094,080 gallons would have been	2176 lbs.
Or the 2416 lbs. coal actually burned in 12 hours would have pumped	1,167,383 gals.
The *duty* on observed evaporation per 100 lbs. coal, on basis of 7½ per cent. ash, is	101.600,000 ft. lbs.

B. E. LEHMAN.

WE regret that various reasons have contributed to delay the publication of the JOURNAL as early in the term as usual, and we hope to be more prompt hereafter.

ON account of the failure to secure the cuts in time, an article on "Easement Curves" intended for this number of the JOURNAL had to be omitted. It will appear in the next issue.

WE are glad to record the increasing interest in the work of the Engineering Society and its publication, and expect that the future numbers of the JOURNAL may prove this by the number and character of the articles contributed.

AT a recent meeting of the Society, the office of "Corresponding Editor" of the JOURNAL was instituted, and Mr. H. S. Jacoby, one of our instructors and an alumnus, was elected to fill the place. It is to be the duty of the Corresponding Editor to solicit papers from our Alumni.

IN the beginning of the present term, the Business Manager sent printed circulars to the Alumni, requesting them to pay the subscription money for the JOURNAL, which had been sent to each of them regularly during the past year, and also to place themselves upon the subscription list for the present year. The replies have been very few in comparison. There is but one way to account for this result. The subscription price is such a small amount to them that the request is laid aside and forgotten. We wish to say it is these small amounts that have to pay for the publishing of the JOURNAL, and we earnestly urge all those who have thus far neglected it to send it in as soon as possible.

THE American Society of Mechanical Engineers held its semi-annual meeting at Philadelphia during the week ending Dec. 3. On Dec. 1 an excursion was made to Bethlehem for the purpose of visiting the Lehigh University and the works of the Bethlehem Iron Company. The train arrived at 10:30, and was stopped at the New Street Crossing, from which the visitors, to the number of nearly three hundred, proceeded directly to the University Park. Packer Hall was the first building inspected, where the visiting Engineers were received by Prof. Klein and other members of the Faculty, who, assisted by the instructors, explained the drawings, theses, and note books of the students, which were displayed in the several drawing rooms. The very large collections of drawings made by the students in civil and mechanical engineering were carefully inspected by the visitors, many of whom expressed themselves as highly gratified by the great variety of the work and the excellence of its execution. Nearly an hour was spent in this manner, after which the Library, Gymnasium, Laboratories and Chapel were visited, and then the party proceeded to the works of the Lehigh Zinc Company and the Bethlehem Iron Company, where they were shown through the shops and mills by the respective

superintendents. The heavy work done in the machine shop of the Bethlehem Iron Company, the large blowing engines, the new buildings for the Government work, the four steel converters and the rolling mills were inspected under the leadership of Mr. Fritz, and the afternoon proved too short for many of the visitors to finish their critical study of the machinery and the methods of this thorough establishment. Among the excursionists were some of the most distinguished mechanical engineers in this country, a number of professors in other institutions and the representatives of several of the leading technical periodicals.

THE officers of the American Society of Mechanical Engineers for 1888 are as follows: President, Horace See of Philadelphia; Vice-Presidents, W. S. G. Baker of Baltimore and Henry G. Morris of Philadelphia; Treasurer, William H. Wiley of New York; Secretary, Prof. F. R. Hutton of Columbia College, New York.

THE Engineers' Club of Philadelphia celebrated the tenth anniversary of its institution on Dec. 15, by a reception held at the headquarters, No. 1122 Girard Street. Bethlehem was represented by J. J. McKee of the Lehigh Boiler Works and by Prof. Mansfield Merriman, both of whom are members of the Club.

AT the meeting of the American Association for the Advancement of Science, held in New York in August last, Hon. Eckley B. Coxe, vice-president of the section of mechanical science and engineering, delivered an able and suggestive address on the necessity of scientific training for engineers. Prof. C. L. Doolittle was elected secretary of the section of mathematics and astronomy, and Prof. Mansfield Merriman was chosen by the section of mechanical science and engineering as its representative in the Council of the Association. Among the new members elected were the following from Bethlehem: Miss Helen Goodwin, Mr. Henry S. Jacoby and Prof. J. F. Klein.

E. DIEBITSCH, '89, is a member of the party for the location of the Nicaraugua Canal which sailed from New York early in December, and which expects to return in June next. The location is under the immediate charge of R. E. Peary, Civil Engineer of the United States Navy, A. G. Menocal being Engineer-in-Chief.

THE Allentown Foundry and Machine Company, manufacturers of the Wolff turbine, have contracted to set up a wheel in the hydraulic laboratory in the University Park. The turbine will be erected in January, so that it may be used during the Spring by the Senior Class in their practical hydraulic exercises. A brief account of the work done last year in the hydraulic laboratory was published in Vol. II. of this JOURNAL, and in a future number it is intended to present a statement concerning the experiments on the efficiency of the Wolff wheel.

ALUMNI NOTES.

1872.

—H. St. L. Coppèe, C. E., was recently elected a member of the American Society of Civil Engineers.

1875.

—Charles J. Bechdolt, C. E., is Assistant Engineer on the Middle Division of the Pennsylvania Railroad, with headquarters at Harrisburg.

1883.

—W. T. Goodnow, C. E., is at Birmingham, Ala.

—G. S. Patterson, E. M., is also located in Alabama.

—John Ruddle, M. E., is Car Inspector for the Central Railroad of New Jersey, with headquarters at Mauch Chunk, Pa.

1884.

—L. B. Semple, B. A., is at the head of the firm of Semple & Ferriday, Paint Manufacturers, Bethlehem, Pa.

—H. T. Harper, C. E., lately on the Lehigh Valley Engineer Corps at Hazleton, is now located at Tower City, Pa.

—F. B. Langston, C. E., is an Architect and has made several excellent designs for dwelling houses, which were lately published in the *Scientific American*.

1885.

—J. B. Price, C. E., has returned from Colorado. and was lately at Mauch Chunk.

—J. R. Engelbert, C. E., is with the Wilkesbarre & Nanticoke Coal Company at Shamokin, Pa.

—W. N. Edson, C. E., is with the Dominion Bridge Company at Lachine Locks, Province Quebec, Canada.

—J. H. Wells, C. E., is engaged on the work for the new tunnel under East River somewhere near Blackwell's Island.

—Felix Freyhold, C. E., is with Junken & Sons, Surveyors and Civil Engineers, 93 Dakota Avenue, St. Paul, Minn.

1886.

—J. S. Siebert, C. E., is with the H. C. Frick Coke Co., Scottdale, Pa.

1887.

—G. F. Yost, M. E., is at Oswego, N. Y.

—A. Bonnot, C. E., is at San Rafael, Cal., and expects to go to San Diego soon.

—J. A. Morrow, C. E., has charge of the construction of water works at Cosohocton, O.

—J. W. Kittrell, C. E., is engaged in the construction of water works with C. F. Knight, C. E., at Rome, N. Y.

—H. S. Meily, C. E., is on the Engineer Corps of the Middle Division, Pennsylvania Railroad, at Harrisburg, Pa.

—C. P. Pollak, C. E., is in the Engineer Office of the Chicago, Milwaukee & St. Paul Railroad at West Milwaukee, Wis.

—J. W. LaDoo, C. E., is also on the construction of water works at Altoona. His address is 1503 Eleventh Avenue, Altoona, Pa.

—J. B. F. Hittel, C. E., is with the Chicago, Santa Fé & California Railroad. His address is 721 Rialto Building, Chicago.

—B. A. Cunningham, C. E., is engaged on the construction of the Lehigh Valley Railroad branch line from Fairview to Pittston.

—E. E. Snyder, C. E., has recently accepted a position with the Louisville & Nashville Railroad, with headquarters at Bay Saint Louis, Miss.

—R. H. Phillips, C. E., is named in a bill just introduced in Congress as one of the incorporators of the Washington Suburban Railway Company. His address is 1428 New York Avenue, Washington, D. C.

OBITUARY.

Elliot Otis Smith, C. E., was drowned in the early part of August while swimming across the Lachine Canal near Montreal, Canada.

He was a member of the Class of 1885, was an excellent student, maintained a very high rank in his class and was loved and respected by all who knew him.

For two seasons after graduation he assisted Prof. Merriman on triangulation work of the Coast Survey, distinguishing himself by the care with which he attended to every detail of the work committed to his charge.

He then entered the service of the Union Bridge Company at Athens, Pa., as computer, remaining over a year, when he accepted a position with the Dominion Bridge Company, whose office is in Montreal, Canada, where he remained until the time of his death.

Though living among entire strangers, the regard in which he was held there was shown by the erection of a stone over his grave.